Big advances in the biological sciences are driving fresh thinking and new approaches to a wide range of problems.

FRANCOIS GAASCHT, A POSTDOCTORAL RESEARCHER IN CLAUDIA SCHMIDT-DANNERT’S LAB, HOLDS A PETRI DISH CONTAINING POLYPORUS. PHOTO BY JENNA PRIVATSKY
Here and now

An exhibition at Northrop Gallery organized by the College of Biological Sciences Conservatory highlights plant-based healing in Minnesota.

Did you know ginseng, a staple of traditional Chinese medicine, was once a major export crop in Minnesota? Or that the state flower, the showy lady’s slipper, was used by the Ojibwe to treat a range of ailments? Virtually every culture provides examples of plant-based healing. As new cultures made Minnesota home, they brought those traditions with them. Roots to Healing: A brief survey of the past, present and future of plant-based remedies in Minnesota explores this intersection of plants, people and place.

“Our goal with this exhibition is to highlight the influence of culture on our perception of plant-based medicine right here in Minnesota and draw attention to the rich history informing our use of specific plants,” says Lisa Aston Philander, curator of the College of Biological Sciences Conservatory and curator of the exhibition. “Medicinal plants, in particular, have and always will play a significant role in culture and healing. Those healing traditions, rooted deep in our past, aren’t just remnants of a bygone era, they are evolving practices.”

Roots to Healing runs through December 31 at Northrop Gallery in Northrop Auditorium. Visit cbs.umn.edu/conservatory for more information.
4 New & noteworthy
Market Science returns to Midtown, around the world in four musical movements, the next chapter for Snapshot Safari

6 Research highlights
A transformative gene-editing technology, engineering enzymes to combat antibiotic resistance, testing the efficacy of cancer treatments faster

12 Bio inspired
Big advances in the biological sciences are driving fresh thinking and new approaches to a wide range of problems

16 Minding the gap
An evidence-based approach to making STEM more inclusive inspires a transatlantic collaboration

18 A different kind of experiment
We know research experiences are essential, but what kind are best for undergraduates?

20 Causes to celebrate
Cedar Creek, Nature of Life, and Ecology, Evolution and Behavior are marking major milestones this year

24 Cheers!
CBS alum Riley Seitz makes sure Surly’s brews are the best they can be
A MESSAGE FROM THE DEAN

Back to basic
To continue to lead the way as innovators, basic biology research is essential.

A lot of what we do at the College of Biological Sciences revolves around basic research. It is an essential undertaking, if a slightly misleading phrase.

As one of the only colleges in the country dedicated to the biological sciences, our researchers investigate life at every scale and collaborate across disciplines in ways very few others can. Our ability to do that at both granular and global scales has never been greater.

Many of our most daunting challenges are biological in nature, and so are the solutions. Our discoveries — rooted in basic biology research — have implications for treating diseases, cleaning up the environment and ensuring we can feed a growing population. Sometimes unexpected insights emerge from this new knowledge.

In the 1950s, Eville Gorham, an emeritus professor in our Department of Ecology, Evolution and Behavior, discovered that the atmosphere transports pollutants much farther than anyone thought at the time. This was important for understanding the causes and consequences of acid rain. He was studying lichens.

In the 1990s, Perry Hackett, a professor in the Department of Genetics, Cell Biology and Development, developed and patented the Sleeping Beauty transposon system. He wanted to figure out a way to get fish to grow faster. Today this technology is used to identify genes that cause cancer and to carry genes into cells for cancer treatment. It is considered one of the most important research achievements in the history of the University of Minnesota.

A number of CBS faculty currently work at the interface between basic and applied research, as well. The results could prove transformative. Their insights could lead to ways of slowing down mutations in cancer, determining how well a leukemia treatment works in days instead of weeks, and cleaning up drugs, excess phosphorus and other pollutants in wastewater, to give just a few examples.

As discussion around funding for research continues to bubble up at the national level, my hope is that as alumni and friends of the College you will champion the importance of basic research. It is vitally important that we continue to invest in the foundational work in the biological sciences that underpins much-needed solutions to the numerous environmental and health challenges we face.

VALERY FORBES
Dean, College of Biological Sciences
A world of plants in one place

Did you know the most diverse collection of plants in the region is right here on the St. Paul campus? The College of Biological Sciences Conservatory brings a world of plants to Minnesota, including many rare and endangered species. Plants are displayed in biome rooms representing specific environments such as the tropics room, pictured here.

PLAN YOUR VISIT
The College of Biological Sciences Conservatory is open to the public! Go to 
<http://cbs.umn.edu/conservatory> for more information.
You might expect to find fungi at the farmers market, but what about butterflies, lichens and salamanders? Those are just a few of the organisms you might encounter at the Market Science booth at the Midtown Farmers Market this summer.

Market Science is a collective of scientists from the University of Minnesota and around the Twin Cities who volunteer to share their knowledge with market-goers through hands-on learning activities and conversation. While a farmers market might seem like an unusual venue for a science lesson, organizer Beth Fallon, a College of Biological Sciences graduate student, says it's a natural fit.

"Farmers markets are spaces for interaction. They draw from across demographics and bring in a diverse cross-section of people from surrounding neighborhoods," says Fallon, who notes that scientists can get as much out of it as the public.

"It's actually a great way to learn how your science is important to people," she says. "A woman stopped at the booth when we were counting tree rings and said her family used a tree ring to map their own family history. I wouldn't have thought of connecting to personal history in that way."

Visitors to the Market Science booth at Midtown Farmers Market and other locations around the metro can learn more about camera traps and carnivores, molecular gastronomy, microorganisms, viral ecology, fungal symbioses, tropical ecosystems and other topics.

Go to cbs.umn.edu/market-science for current locations and topics.

Around the world in four musical movements

“Biomes” takes inspiration from the global footprint of medicinal plants found here in Minnesota.

Minneapolis-based musician LOTT created a composition inspired by the College of Biological Sciences Conservatory’s unique collection of “biome rooms” to coincide with a new exhibition that explores plant-based healing in Minnesota. The piece, titled “Biomes,” evokes the tropics, the desert and other environments highlighted in the exhibition Roots to Healing: A brief survey of the past, present and future of plant-based remedies in Minnesota at Northrop Gallery.

Watch LOTT perform in the Conservatory’s biome rooms at z.umn.edu/LOTTmusic.
Snapshot Safari takes off
Craig Packer and his team are setting up camera traps across southern Africa in hopes of boosting conservation efforts by identifying best practices.

The future of Africa’s wildlife seems bleak. Lion, cheetah, rhino, elephant and giraffe populations all suffered catastrophic declines in recent decades. However, Africa is also home to successful restoration of endangered species in South Africa, Malawi, Rwanda, Botswana, Chad and Kenya. Lion expert Craig Packer and his research team are expanding on the success of their Snapshot Serengeti project, which generated a tremendous amount of data on wildlife on the Serengeti Plain with the help of citizen scientists around the world. They are adapting the strategy to a new task: Pinpointing conservation strategies that work in areas where endangered animals flourish. To do that, they are setting up camera-trap grids in dozens of wildlife parks across southern Africa. Snapshot Safari will enable the researchers to identify the areas managed most successfully and, by extension, the conservation strategies that work. So far, they’ve set up 840 cameras in 17 reserves. Stay tuned!

Learn more about the Snapshot Safari project and how you can help it grow at z.umn.edu/snapshotsafari.

Where has life taken you since Nature of Life?
Ask a recent College of Biological Sciences alum about their most memorable moments as an undergraduate and more likely than not Nature of Life will come up. This summer, as another class of incoming students make its way north, we’re asking Nature of Life alums to don their trademark tie-dye T-shirts and help celebrate the program’s 15th anniversary!

“Building a strong community early on is one of the central purposes of NOL@Itasca,” says Rob Kulhanek, a former teaching specialist for Nature of Life and a CBS alum. “Students start as strangers, but by the time they leave Itasca many feel a real sense of belonging and have built the beginnings of strong friendships.”

If you started your CBS experience at the headwaters of the Mississippi, show us where you are now!

Share a photo yourself “on location” in your Nature of Life shirt on Instagram, Facebook or Twitter and be sure to tag us (@umncbs), for a chance at a commemorative Itasca-themed Nature of Life mug!
A princess sleeps for years in an isolated tower. Then, one day, a knight arrives ... and everyone lives happily ever after. That tale of reawakening is not just the plot of a classic fairy tale, it’s also a story time version of the work done by scientific knight errant Perry Hackett, aided in his work by what he describes as “dedicated bench work by teams of hard-working young folks who shared a vision.” Hackett is a professor in the Department of Genetics, Cell Biology and Development; a member of the Center for Genome Engineering and the Masonic Cancer Center’s Genetic Mechanisms of Cancer Program; and co-founder of two Twin Cities-based biotech companies — Discovery Genomics, Inc., and Recombinetics, Inc.

His Sleeping Beauty (SB) transposon, reconstructed from a fish DNA sequence that went extinct 13 million years ago, proved to be a game-changer in non-viral cancer gene therapy. The result of his work to awaken long-sleeping potential from genetic material may lead to faster, less expensive and potentially safer methods to deliver DNA at a cellular level. The technology was licensed for use in treating cancer to the M.D. Anderson Cancer Center in Texas and to Boston-based company, Ziopharm.

Sleeping Beauty was just the beginning, Hackett says. With several teams of scientists now in place at the University along with the launch of several small biotech companies, he’s more excited about the impact of the combined work of many colleagues with the potential to increase food, nutrition and animal welfare for a growing global population. In recognition of his work and for his contributions toward making the University and the state of Minnesota a genomics and gene-editing powerhouse, Hackett received the University of Minnesota Office for Technology Commercialization’s biennial Impact Award. The award recognizes a researcher whose work has had a broad, positive impact on society and improved quality of life.

“The story is so much bigger than one

13 million years in the making

Perry Hackett’s Sleeping Beauty transposon has far-reaching implications for identifying causes of disease, use in gene therapy and more.
person,” Hackett says. “We started a snowball rolling down a slope, and it has accumulated considerable mass and momentum, gaining an enormous potential.”

He was nominated for the award by Dan Voytas, professor of genetics, cell biology and development, and director of the Center for Genome Engineering, which Hackett helped found. “One of the reasons I came to the University was because I was excited about the work Perry was doing here,” says Voytas. “There is an energy and a great sense of possibility among the scientists.”

In addition to being an esteemed researcher, Hackett has contributed to the advancement of his field through significant financial support. He was instrumental in creating multi-million-dollar research funds to support innovation and entrepreneurship in the field of biotechnology. “As director of this center, we’ve benefited from funding from the Hackett Fund for Genome Engineering,” says Voytas, “and we recognize that Perry has been a great philanthropist for the work of his fellow scientists.” —JULIE KENDRICK

**WHAT’S AHEAD:**

*From medicine to agriculture*

While the Sleeping Beauty transposon is known for its impact on biomedical science, Hackett predicts that he and his colleagues are poised to tackle an even greater challenge — feeding a growing population.

Hackett cites Norman Borlaug, one of the University’s most celebrated alums, who said that genetic engineering will be needed to meet the growing demand for food going forward.

Companies like Recombinetics and Calyst, a biotech startup launched by Voytas, are already making strides in this area. “[Calyxt] is using genome editing to develop crops with healthier characteristics, and Recombinetics is doing the same in animals,” says Hackett.

“The Center for Genome Engineering is going to be the leader in 21st century agriculture for the entire world,” he predicts. “We are becoming the hub of genome engineering agriculture research. Within a decade, people will recognize how truly important the work being done here has been.”

“*We are becoming the hub of genome engineering agriculture research for the world. Within a decade, people will recognize how truly important the work being done here has been.*” —JULIE KENDRICK

**Findings**

Female Cope’s gray tree frogs tune out the cacophony of frog calls and home in on calls from potential mates by discerning — and selectively ignoring — patterns in background noise. This finding could contribute to better designs for hearing aids and voice recognition software. (Associate Professor Mark Bee, postdoctoral fellow Norman Lee and colleagues in the March 2017 edition of *Current Biology*)

Households are the main culprit when it comes to nutrient pollutants in the Twin Cities urban watershed. Lawn fertilizers and pet waste are the dominant sources of nitrogen and phosphorus pollutants in the Mississippi River. (Professor Sarah Hobbie and colleagues in the April 2017 edition of *the Proceedings of the National Academy of Sciences*)

When species such as Asian elephants and bluefin tuna decline in number, the geographic areas they inhabit also shrink. Where populations manage to remain locally abundant they become increasingly easy targets for hunters and fishermen, making them more vulnerable to extinction. (Assistant Professor Allison Shaw, postdoctoral fellow Lauren Sullivan and colleagues in the April 2017 edition of *the Proceedings of the National Academy of Sciences*)

Molecular chaperone TorsinA plays a key role in establishing and maintaining cell polarity, highlighting the potential connection between defective cell polarity and the human neurological movement disorder DYT1 dystonia. (Assistant Professor G.W. Gant Luxton and colleagues in the February 2017 edition of *The Journal of Cell Biology*)
Exploring the possibilities
Mikael Elias is turning a serendipitous discovery into a tool for beating bacteria at their own game.

They say opportunity knocks at least once on everyone’s door. In Mikael Elias’ case, it took an astute eye to recognize it, seeing as how it was disguised as bacterial slime. But it’s a good thing he did. Answering that knock led the assistant professor of biochemistry, molecular biology and biophysics to develop a molecular tool that holds promise for diverse applications from fighting disease to improving Great Lakes shipping. This spring, it also earned him an Early Innovator Award from the University’s Office of Technology Commercialization.

“Mikael Elias has been truly amazing with respect to his research output, and a significant amount of that has been translational to applications in biotechnology,” says Distinguished McKnight University Professor Larry Wackett. Just three years into his faculty career, Elias holds four patents, is in the process of filing provisional patents on three other inventions, and is working with two multinational companies to commercialize products based on his discoveries.

It all started when he was a Ph.D. student at Aix-Marseille University in France in search of an enzyme that could degrade toxic insecticides but would be durable enough to withstand industrial processes. Figuring that extremely durable substances are most likely to be found in extremely challenging environments, he looked for — and found — a promising candidate molecule made by microbes living in hot springs on top of Mt. Vesuvius in Italy. Unfortunately, though it was indeed able to break down insecticides, the enzyme was too sluggish to have a practical application. “I was annoyed. It was not fulfilling my objectives at all,” Elias says. But instead of calling it a dead end, he decided to investigate what else the enzyme could do. A search of the scientific literature showed that it could disable a molecule bacteria use to send signals among themselves. That’s when the light bulb went on. “If you have an enzyme that breaks down these molecules, you actually disrupt bacterial signaling,” he says. “And if you disrupt bacterial signaling, you prevent them from coordinating behaviors.” In other words, the enzyme could, under the right conditions, help reduce bacterial virulence, keep water supplies safe and lots more.

Elias went on to other projects as a postdoctoral fellow at the Weizmann Institute of Science in Israel. “But I kept this in mind,” he says. After the University of Minnesota lured him in 2014 with its reputation for interdisciplinary collaboration, he turned again to the enzyme and began working on ways to make it more stable and faster acting. “I have a bias of always keeping an eye on what are the possibilities.”
Reciprocity-based research
Doing research in the rainforests of Papua New Guinea requires more than science acumen.

George Weiblen made some big discoveries through his fieldwork in Papua New Guinea, but that’s not all he achieved in his two decades doing research there. He established the first large-scale, long-term forest study plot in Oceania. He co-founded the New Guinea Binatang Research Center, where he trains local people in biology and conservation. He helped establish a 20,000-acre conservation area and even a public elementary school. All those undertakings required a willingness to engage with the people as well as the place.

Earlier this spring, the University of Minnesota recognized Weiblen for his deep commitment to connecting with communities both here in Minnesota and halfway around the world with its 2017 President’s Community-Engaged Scholar Award.

“Customary land ownership means that you can’t set foot in the rain forest without intruding on somebody’s backyard,” says Weiblen. “Community engagement, respect and reciprocity are essential first steps.”

In the course of his fieldwork in the island nation, Weiblen involved the local community every step of the way, from locating and identifying plants to developing and implementing conservation strategies to preserve the area’s incredible biodiversity.

“New Guinea is a kind of last frontier for botanical discovery with at least 20 times more plant species than Minnesota. Nobody knows exactly how many because much of the forest remains unexplored. Countless species await scientific names if only we can locate them in time,” says Weiblen. “I first visited New Guinea to catalogue tropical trees but, year after year, I return there for an ongoing exchange of knowledge with indigenous landowners whose future depends on the fate of the forest.”
But is it working?

A new process developed by Laurie Parker and colleagues aims to determine the effectiveness of chemotherapy faster.

When you are diagnosed with cancer, time is everything. Each tick of the clock is an opportunity for the malignancy to gain ground. So it’s not surprising that strategies to speed the application of effective therapies are in demand.

A new process developed by biochemistry, molecular biology and biophysics professor Laurie Parker and colleagues Tzu-Yi Yang (a postdoctoral researcher in the Parker lab) and Jo Davison of Purdue University has the potential to do just that. The process represents a rapid and accurate tool for telling how well kinase inhibitors work for a particular patient. Kinase inhibitors are chemotherapy drugs that block the activity of kinases, molecules known to be overactive in leukemia and some other forms of cancer. That, in turn, makes it possible to modify treatment plans early on to maximize effectiveness and minimize wasted time and treatments.

The invention’s value lies in its ability to measure how well kinase inhibitors are working. Several years ago, Parker and her colleagues developed a way to make a “biosensor” to test for kinase activity within living cells. With this most recent innovation, they present a way to label these probes with different isotopes, “so you can have multiple copies of the biosensor being analyzed at the same time, but you can tell them apart,” Parker says. That means the test can be performed on multiple tissue samples at the same time, speeding the testing and making it more accurate since samples taken before and after treatment starts can be analyzed under the exact same conditions.

In addition to providing timely information on how well a particular chemotherapy works on a patient, the innovation could dramatically improve clinical trials of new cancer drugs. And because kinases play a role in diabetes, as well as metabolic, neurodegenerative, immune and other diseases, cancer treatment is just one of many potential applications.

“Anywhere some kinase activity is going haywire is somewhere these tools could be used,” Parker says.

Parker is starting to work with University of Minnesota clinicians and clinician scientists toward applying the process to pediatric cancers. She is working with a company started by one of the graduate students involved in the research to apply a related innovation to drug discovery.

Having lost both a grandfather and uncle to leukemia, Parker says she constantly reminds herself that her work could someday make a literal life-or-death difference to people. It’s easy to get caught up in the research and “forget it’s all about these people we’re trying to do something for,” she says. “I want to make sure that stays our focus.” —MARY HOFF
THE REWARDS OF RESEARCH
Dave Tilman reflects on his academic career as a newly elected member of the Royal Society of London.

This July at a ceremony in London, Regents Professor David Tilman will sign his name in a book containing autographs dating back to the 17th century, officially taking his place among Isaac Newton, Charles Darwin, Albert Einstein and other eminent scholars from across the ages as a member of the Royal Society of London.

Already a fellow of the American Academy of Arts and Sciences, a member of the National Academy of Sciences and the recipient of the Balzan Prize, Tilman will be honored for his seminal contributions to our understanding of the importance of biodiversity. We asked him to reflect on his career so far and share thoughts about what’s next.

How did you get started in ecology?
From a very young age I liked anything mechanical or scientific. My mind was a sponge for absorbing and wondering about why things are the way they are. In college I was planning to be a physics major. My sophomore year I took a biology class, and I was taken by the major questions that were unanswered in ecology. At the time, it was a very descriptive science. I saw the need for a mechanistic perspective, for theory that could predict how ecosystems function. And, it was clear theory would have to be tested with rigorous experiments. I felt that only such an approach would let us know how ecosystems would be impacted by different human actions and the policies we would need to keep ecosystems sustainable. I’ve pursued these questions with my whole heart and soul ever since.

What do you consider your greatest accomplishment so far? Having a wonderful family. On the scientific side, it was the 20-year-long discovery of the incredible importance of biological diversity to how ecosystems function. Grassland systems, forests, oceans, lakes, microbial communities — the underlying ecology is pretty much the same. It means biodiversity matters.

How do you define success? I never tried to be successful in the eyes of others. I’ve just worked to answer the questions that I thought were important. I take joy in each of the scientific mysteries my students, collaborators and I have solved. It has been surprising and gratifying that others have found our work to be interesting and insightful.

What advice do you have for young scientists? Pursue the big, bold questions that you feel are really important, and when you answer one, ask yourself what the most important question is now. Also, read and learn from the really great early ecologists — Darwin, Wallace, Elton, Hutchinson, and others. It can let you perceive patterns and relationships and processes through the eyes of someone who spent decades looking at nature in the way that no one ever does anymore.

What do you still want to accomplish? There are environmental problems for which we don’t know solutions, and there are many solutions that are not yet adopted. For the rest of my career I’d like to both find those solutions and find ways to have those solutions be adopted so that all future generations can live in a truly sustainable world.

We now know there are no technological or conceptual barriers to having a sustainable Earth at the same time that all people live full and secure lives. The only barrier is our willingness to act. With communication, education, ethics and laws, we can create a better way of living.

How will you celebrate? I want to absorb the history and fellowship of the Royal Society. And, I hope to have my children and grandchildren with me in London. Our time exploring the city will be our celebration. I love science, but family is number one.
Big advances in the biological sciences are driving fresh thinking relating to a wide range of problems. We asked several CBS researchers to reflect on new approaches to combating biodiversity loss, cleaning up chemicals, treating disease and boosting crops while protecting the environment.
Some call the 21st century the “century of biology,” and the early returns suggest that this rather lofty designation has merit. In less than two decades, the amount of information about the living world available to us expanded exponentially thanks to advances in genome sequencing. Cross-pollination with computer science, math and engineering continues to add to our capacity to make sense of that information and put it to work. At the same time, the proliferation of ever-more-precise approaches to gene editing open the door to tremendous potential to shape the future.

That future is unfolding in labs and offices around the world. But few places can match the University of Minnesota for scientific scope and cross-disciplinary capacity. A critical mass of researchers in biology-based disciplines and other STEM fields creates the precise conditions that are driving advances in the biological sciences, making the College a microcosm of the seismic scientific shifts underway.

“It is truly exciting to watch what can happen when different disciplines or subdisciplines are brought together in new ways,” says College of Biological Sciences Dean Valery Forbes. “In combination with incredible advances in computational and other technologies, this multidisciplinary, team-based approach to science is remarkably powerful and clearly the way forward.”

We asked CBS researchers who work at the intersection of disciplines within and beyond biology to reflect on possible bio-inspired paths forward in a number of key areas. —STEPHANIE XENOS

MINING MUSHROOM GENOMES FOR MEDICINE

Claudia Schmidt-Dannert isn’t your typical mushroom hunter. She finds fungi fascinating for the chemical compounds they contain. Schmidt-Dannert applies very modern techniques to identifying the therapeutic potential in a very old old source of medicine.

For thousands of years, people around the world turned to Basidiomycota — the type of fungus we typically think of when we think “mushroom” or “toadstool” — to relieve infections, lower blood pressure, even treat cancer. Mushrooms’ pharmaceutical potential first caught Schmidt-Dannert’s attention because their use in traditional medicine suggested they contain compounds that deter bacteria, microscopic fungi and other things that harm us.

In the wild “these type of fungi have to defend [themselves] against grazing insects and invertebrates,” Schmidt-Dannert says. “So the hypothesis is that they must make compounds that fend off other higher organisms.”

Schmidt-Dannert has already sequenced the genome of the jack-o-lantern mushroom, which is known to produce anti-cancer compounds. Building on the knowledge gained from that research, she gathered nearly two dozen other types of mushrooms from her neighborhood to grow in culture, then test for pharmaceutical properties. If a particular fungus appears promising enough, she’ll sequence its genome in order to pinpoint the specific genes it uses to construct the pharmaceutically active compounds. Her ultimate goal is to insert the genes into bacteria that can then mass produce the useful substances.

Schmidt-Dannert is unlikely to run out of research material anytime soon in her quest to turn the wisdom of the past into the cures of the future. Scientists have already identified some 30,000 species of mushrooms, but they estimate there could be 15 times that many that we don’t even know about.

Claudia Schmidt-Dannert is a Distinguished McKnight University Professor in the Department of Biochemistry, Molecular Biology and Biophysics and a member of the BioTechnology Institute.
There are about 100,000 different chemicals used in products, services and manufacturing. Some of these chemicals end up in our water supplies. Factories, farms, hospitals and homes all contribute their share. Traditional approaches to water treatment are no match for this onslaught of chemicals.

The good news? Advances in...

Finding Enzymes to Clean Up Chemicals Faster

Larry Wackett studies microbial enzymes with a unique ability to break down chemicals. So far, he identified and harnessed enzymes that can take on melamine in milk and excess cyanuric acid in swimming pools. Now, Wackett and his team are developing novel enzyme-based approaches to removing common chemicals — including compounds from prescription and over-the-counter drugs — missed by standard water filtration processes. We asked for his insight on a promising new approach to removing chemicals from water.

Helping Species Survive Climate Change

Jessica Hellmann has thought a lot about the potential impacts of climate change on ecosystems. She focuses on how climate change can cause major ecological disruption especially for endangered species. As an ecologist, Hellmann is keenly aware of the current challenges to ecosystems and organisms, and the need for a more holistic approach to studying the dynamics driving adaptation. We asked her for her thoughts on how we might preserve biodiversity as the climate changes.

Without a significant reduction in CO₂ emissions, global temperatures may increase by up to 6° C by the end of the century. The scope of change will likely require proactive measures to preserve biodiversity, which is why Hellmann and other scientists are exploring climate management strategies that could offset some loss of biodiversity. While these strategies come with trade-offs, they provide hope for maintaining some of the planet’s species as ecosystems transform due to changes to the environment caused by human activity.

Hellmann points to three strategies that may come into play: assisted migration (moving organisms to areas where they are likely to thrive), ex situ conservation (preserving biological diversity outside of natural habitat) and strategic resistance (highly managed efforts to maintain organisms in their current ecosystems). All require an integrated approach to studying organisms within the context of ecosystems in order to better predict the direction they may move or identify the best place to relocate them.

To that end, Hellmann points to the need for greater crossover between ecology, genetics and evolutionary biology in the interest of identifying key differences within species. “While we often think of ecology and evolution as separate subfields, they are two sides of the same coin for living things. Ecology is a force that molds evolution, and evolutionary history is a strong influence on how species respond to changes in their environment on ecological time scales,” Hellmann says. “My work tends to focus on the latter and argues that ecologists and conservation biologists need to consider evolution and genetics when they think about the future for species; evolution is not just about their past.”

Jessica Hellmann is director of the Institute on the Environment and a professor in the Department of Ecology, Evolution and Behavior.
FEEDING THE WORLD WITH PHENOMICS

Nathan Springer loves thinking about a good problem and there are a wealth of good problems in agricultural genetics. In his quest to understand the basis for heritable variation within a species, Springer looks to phenomics for insights. Phenomics brings together biology, engineering and computer science to illuminate how physical and biochemical traits change in response to genetic mutation and environmental influences. We asked him to share his perspective on how this emerging cross-disciplinary field might influence agriculture in the future.

The world population could reach nine billion by mid century. At the same time, growing key crops could get trickier due to the uncertainties created by climate change. Ensuring a steady food supply will require continued innovation. Insights may come, in part, from the emerging field of phenomics. A more nuanced understanding of the role of phenotypes — observable traits that derive from interaction between genes and environment — as well as the relationship between phenotype and genotype could make it much easier to identify traits that allow plants to thrive under less than ideal circumstances.

Springer and his colleagues at the University’s Center for Applied Phenomics collect plant phenotype data with an eye to developing optimal plant varieties and increasing productivity, but also minimizing the negative environmental effects. A better understanding of the role of the traits we can see and their genetic underpinnings could make it possible to one day monitor the health of individual plants and deliver highly targeted applications of fertilizers, pesticides and water.

Connecting the dots between genotype and phenotype remains a challenge, but it’s a critical step toward forming a more complete picture of the role each plays. Springer and others are deploying sensors, drones and other technologies to gather detailed data on plant traits. While these efforts are still gathering momentum and progress is slower than Springer and others would like, the eventual upsides could be huge. And phenomics is just one of a number of fields made possible by rapid advances in the biological sciences.

“We are now able to think about genetics in ways that were considered impossible just 10 years ago,” says Springer. “There are some really exciting new technologies and areas of research in the basic sciences right now that are likely to affect agriculture in the future. Genome editing, plant-microbiome interactions and systems biology approaches are all likely to have major impacts.”

Larry Wackett is a Distinguished McKnight University Professor in the Department of Biochemistry, Molecular Biology and Biophysics and a member of the BioTechnology Institute.

Genome editing, plant-microbiome interactions and systems biology approaches are all likely to have major impacts.

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Nathan Springer is a McKnight Presidential Endowed Professor in the Department of Plant and Microbial Biology.
MINDING THE GAP

Taking an evidence-based approach to making STEM more inclusive.
Women make up about 60 percent of biology undergraduates in the United States, but only 36 percent of assistant professors and 18 percent of full professors. It’s a significant gap in representation, but pinpointing a reason for the precipitous drop-off remains a challenge. Sehoya Cotner and Cissy Ballen want to figure it out.

“Biology isn’t a male-stereotyped field yet there’s this female attrition as women progress through the STEM pathway that’s leading them away from science, and this extends to other underrepresented groups as well,” says Ballen, a postdoctoral researcher in the Department of Biology Teaching and Learning. Ballen who works with Cotner, a member of the department’s faculty.

Ballen discovered an interest in STEM equity, an area of inquiry focused on issues like the gender gap in the sciences, while still an undergraduate. Before heading off to graduate school, Ballen worked in Cotner’s lab. The pair investigated the impact of instructor gender on students’ confidence in their ability to do science. They found that female students with female instructors and teaching assistants gained the most confidence.

A transatlantic experiment
During a trip to the University of Bergen in Norway to present the research, Cotner saw an opportunity to dig deeper into the dynamics that might be driving their findings.

“One of the Norwegian faculty commented that I would not see such gender differences in confidence in Norway. That got me thinking,” says Cotner, who notes that Norway consistently ranks at the very top in measures of gender equality. “I wanted to test that assertion.”

With Ballen done with graduate school and back in Cotner’s lab, the duo embarked on a transatlantic research collaboration that’s yielding new insights into gender disparities in levels of engagement in biology courses.

Cotner and Ballen began surveying Norwegian students and making in-class observations of student participation.

Initial results suggest that the female students in Norway who took part in the study participated in class at a lower rate than their Minnesota counterparts. While they were surprised at first, the researchers have since developed a hypothesis about why that may be, and it starts with the way courses are structured.

One big difference: The students in Norway learned in a traditional lecture hall, while the Minnesota undergraduates learned in active-learning classrooms in which students work in smaller groups. In active-learning classrooms, women participated roughly on par with their enrollment in the class. In the Norwegian lecture hall-based course, women participated far less than would be expected given their numbers.

Classroom microclimate
“We began to realize that the social climate overall may matter less than the microclimate of the classroom,” says Cotner. She suggests that the decentralized, team-oriented structure of active-learning classrooms may lower “stereotype threat” in which a person feels more risk associated with an action when they perceive themselves associated with a stereotype. In this case, says Cotner, women may be wary of participation in large lecture hall-style classes for fear of being seen as less capable or qualified than men if they make a mistake. So, better not to participate at all.

“We think women in active-learning classrooms may experience less risk,” says Cotner. “The space is more student-centered, which makes communication easier. And once you’ve discussed a topic with a small group of peers, you might be more willing to share thoughts with the whole class.”

Comparing classroom participation in Norway and Minnesota is just one line of inquiry in the area of STEM equity for Cotner and Ballen. They also launched a network with institutions in several states to investigate barriers related to gender, ethnicity and first-generation college students.

“We’re excited to test this idea that the classroom climate may be more important than regional effects relating to overall social climate,” says Cotner. The researchers are also looking at how instructors grade. “We see a trend in many classes. As faculty migrate to a diversity of assessment strategies such as in-class quizzes, assignments and reports in addition to high-stakes exams, females perform better in the course on the whole,” says Cotner. “We’re currently testing this model in several courses. Stay tuned!”

—STEPHANIE XENOS
Almost every College of Biological Sciences student participates in research at some point as an undergraduate. The benefits are clear. They learn to think and act like scientists, not just absorb information. Research experiences sharpen critical thinking and offer the chance to acquire valuable skills.

Different types of research experiences offer different degrees of autonomy in the questions asked, the design of the experiments, and the approach to generating data and analyzing results. Students’ research experiences range from working with petri dishes, pipettes and other familiar tools in “wet labs” to computer-based projects in “dry labs.” But which type of experience yields the greatest return?

Researchers in the Department of Biology Teaching and Learning (BTL) — a department dedicated to identifying evidence-based best practices for teaching biology — want to find out. “I would like to know what features of these research experiences are most effective or helpful for students’ development,” says Catherine Kirkpatrick, a teaching assistant professor in BTL. “Knowing what kind of impact computational projects have versus wet lab projects is one thing we’re looking at.”

Kirkpatrick and colleagues are evaluating the effectiveness of both kinds of research experience in the Foundations of Biology courses. They are looking at the skills and knowledge students attain from wet lab projects evaluating zebrafish toxicology and dry lab projects focusing on coding and bioinformatics.

“We’re aiming to give students the chance to develop a question and answer that question through a few different means, and evaluating from there,” says Kirkpatrick. Ultimately, she and her colleagues in BTL want to translate the active-learning approach used in Foundations of Biology and other courses to the lab, giving students the opportunity to develop and drive their research from concept to conclusion.

“Our goal is to expose students to all that science entails,” says Kirkpatrick. “By doing that, they develop a technical and analytical skill set that they might otherwise not acquire unless they go on to graduate school, if then,” says Kirkpatrick. “Those are good skills to have.” —LANCE JANSEN
A capital opportunity

Professor Robin Wright, who launched the first-of-its-kind Department of Biology Teaching and Learning and led efforts to introduce active-learning classrooms at the University of Minnesota, was appointed director of the National Science Foundation’s Division of Undergraduate Education in Washington, D.C.

“I’m very excited and humbled by the opportunity to serve as a leader and advocate for undergraduate science education at the National Science Foundation,” says Wright. “The NSF has arguably done more to advance science education in the United States than any other organization and has been pivotal for the emergence of discipline-based education research.”

Wright began a four-year term in her new role at the National Science Foundation this spring.

Making space for student-driven research

Creating opportunities for students to ask and answer their own research questions, particularly those with real-world relevance, is key to nurturing a passion for science. But curiosity-driven research requires the right kind of space where students can interact, explore and try new things. Walk into a typical teaching lab and you’re likely to encounter rows of lab benches with microscopes, cabinets full of pipettes and other equipment, and little space for much else. The College is looking to change that by renovating old labs in the Biological Sciences Center building on the St. Paul campus, turning them into “active learning labs” with an eye toward enabling collaboration, computation and experimentation.

Democracy in his DNA

Newman Civic Fellow Gemechu Mekonnen wants science students to participate in the political process.

When the opportunity to get involved in a nonpartisan effort to encourage students to vote in the elections last fall presented itself, College of Biological Sciences undergraduate Gemechu Mekonnen didn’t hesitate. As student ambassador for the CBS Democracy Project, he helped facilitate conversations about voting as a civic responsibility. In April, he received the Newman Civic Fellowship for his work on the project. The one-year fellowship brings outstanding student problem-solvers together through a national network focused on making positive change across the country.

Mekonnen bridges biology and politics with a double major in genetics, cell biology and development and political science. He volunteers as an assistant in the Medical School for a project on substance abuse in Minneapolis’ East African communities and as a researcher for a professor in the Law School whose work examines recent executive orders and international law. He looks forward to the opportunities to partner with University and community leaders that the national fellowship provides.

“I’m inspired to build on the work of engaged researchers, educators and professionals I meet,” he says, “and the Newman fellowship will give me access to a vast network of those people.”
More than seven decades ago, a graduate student named Raymond Lindeman made seminal discoveries that set the stage for work that informs our current understanding of ecosystem ecology. He made his field-shaping discoveries at what is now Cedar Creek Ecosystem Science Reserve, one of the most famous sites in the world for long-term ecology research. Lindeman was the first of many noted researchers to put down roots at this living laboratory. Ecologists David Tilman, Peter Reich, Sarah Hobbie and others bring that legacy forward to the present. Over the years, Cedar Creek researchers developed radio telemetry to track animals and established the importance of biodiversity in maintaining ecosystems. The nine-square-mile research station remains a beacon for scientists from around the world and, in recent years, has become the epicenter for global-scale research on the effects of nutrient availability on grassland biodiversity through research connected with the Nutrient Network co-founded by Cedar Creek investigators Elizabeth Borer and Eric Seabloom.

At Cedar Creek, we are seeking the knowledge and wisdom needed to simultaneously sustain Earth and humanity.” — Regents Professor and Cedar Creek Director David Tilman
The college marks anniversaries big and small in 2017.

**ECOLOGY, EVOLUTION AND BEHAVIOR TURNS 50.**
From lion behavior to biodiversity, acid rain to bacterial evolution, the insights generated by Department of Ecology, Evolution and Behavior researchers over the past five decades contributed to its reputation as a wellspring of discovery. The new knowledge that has emerged over the years shaped and sometimes challenged prevailing views — from Margaret Davis’ findings on how ecosystems respond to environmental change to Eville Gorham’s discoveries about acid rain and nuclear fallout based on his studies of lichens to David Tilman’s influential insights into the value of biodiversity. The department, which launched in 1967, continues to attract top researchers in evolutionary biology, animal behavior and ecology working on a wide range of questions from the causes of pollution in urban lakes and rivers to sexual behavior in crickets to brain plasticity in butterflies under changing environmental conditions. The common denominator: Discoveries that shed light our world and ourselves.

**NATURE OF LIFE AT ITASCA TURNS 15.**
This summer, incoming students will make their way to Itasca Biological Station and Laboratories for the 15th year of Nature of Life. One of the College’s signature programs, Nature of Life provides students with a brief immersion in the biological sciences and an introduction to college life. From taking canoe rides on Lake Itasca to tromping through bogs in galoshes to hanging out by the campfire, the shared experiences accrued over four days at the station stick with students long after they board buses back to the Twin Cities. On their first day of fall semester back on campus, students wear their maroon-and-gold tie-dye T-shirts, making it easy to find their peers.
A decade ago, the College of Biological Sciences led the way in reinventing how biology is taught with the introduction of technology-rich, active-learning classrooms that put students in the driver’s seat. In these reimagined spaces, students work together in small groups. They share information and engage in discussion. They come up with solutions to real-world problems. *Science* even singled out the approach applied in the Foundation of Biology courses with its Prize for Inquiry-Based Instruction a few years ago.

The college is poised to do it again with the introduction of active-learning labs — flexible spaces where students can develop and run experiments, exchange ideas with their peers and analyze results. A plan is in the works to turn several conventional, crowded lab spaces in the Biological Sciences Center on the St. Paul campus into active-learning labs where students can engage in the entire process of science from asking their own original research question to making discoveries no one else has made.

The College of Biological Sciences Conservatory is also poised for transformation. The Conservatory houses the most diverse collection of plants in the region. Organized into “biome rooms” representing a range of environments from desert to tropics, the collections demonstrate basic evolutionary concepts in a way that is visceral and engaging, inspiring curiosity and appreciation for plants and the role they play in our lives.

The building housing this precious collection is falling apart. It must be replaced. The need is acute, but it also opens up the possibility of creating a space that is more accessible and energy efficient. The good news is that the Minnesota Legislature allocated $4.4 million in the recent bonding bill for a new facility. While state support takes us part way to the goal, private support is needed to fully fund the project.

The CBS Conservatory and active-learning labs are essential to learning, experimentation and collaboration. The College is committed to advancing these critical projects with the help of the CBS community, we will continue to reinvent spaces on campus for the benefit of our students and the broader community.

**Reede Webster**
Director of Advancement
A FAMILY AFFAIR

The Gaasedelens’ philanthropic commitment to education extends all the way to the headwaters of the Mississippi River.

From the beginning, the Gaasedelen family’s milestone moments have had a University of Minnesota connection. Jim (Dentistry ’78) and Allison (Microbiology, ’83) met in a physiology lab when he was a dental student and she was an undergraduate-level lab technician. Their son, Erik, was conceived through cutting-edge IVF technology pioneered at the University. Bringing it all full-circle, Erik (Neuroscience, ’14) is now a Ph.D. student in Professor Paul Iaizzo’s Visible Heart Lab. As a member of the Bioinformatics and Computational Biology program, his particular areas of interest are artificial intelligence, neural networks and the interface between biology and computers.

Long-time donors to the University of Minnesota, the School of Dentistry and the College of Biological Sciences, the Gaasedelens are strong believers in the value of education.

“Supporting the work being done at the University and its colleges is a good investment for everyone in the state,” Allison says. “It’s the key to the future for all of us,” adds Jim, who has had a private dental practice for nearly four decades.

The Gaasedelens recently followed their philanthropic impulses in a new direction, making a generous contribution to Nature of Life, a program for incoming students at the College of Biological Sciences’ Itasca Biological Station and Laboratories in Itasca State Park. The four-day immersion in a pristine living laboratory at the headwaters of the Mississippi River is a treasured memory for many CBS alumni. Some students return to the station as peer mentors, take field courses or make their way back to Itasca for graduate program retreats.

After participating in Nature of Life as an undergraduate, Erik returned last summer for a graduate-level neuromuscular junction seminar. Recalling that he had the opportunity to go fishing with Professor Iaizzo and Professor Will Durfee during some seminar downtime, Jim says, “It’s great to offer a program that’s educational, but one that can offer some time for recreation, too, especially in such a beautiful part of Minnesota.”

Erik started university life as a Post-Secondary Enrollment Options student. “He was ready for the challenge of college-level work, and we’re so grateful he had that opportunity,” Jim says. Allison encouraged Erik to consider the College of Biological Sciences, which he joined as a freshman. With their son enrolled at Allison’s alma mater, they had the opportunity to get to know Dean Emeritus Bob Elde. He was leading a fundraising effort to build a new campus center at Itasca at that time, and he urged the Gaasedelens to consider making a gift to support Nature of Life.

“[Bob] convinced us of the importance of the program and the need to keep it robust through donor funding,” Allison explains. “It touches nearly every student in the college. It’s a unique common experience that builds strong bonds among the students.”

For their part, the Gaasedelens remain a family bound together by a love of science. Jim describes wanting to learn more about the Visible Heart Lab through Erik’s enthusiasm for the work being done there.

“We got a chance to take a ‘tour’ of the human heart using virtual reality goggles,” says Jim. “We love to talk about new scientific theories and exchange ideas,” Allison says.

—JULIE KENDRICK
CBS alum Riley Seitz helps make sure Surly’s beer is at its best.
Building a quality control lab from the ground up for a burgeoning brewery wasn’t what Riley Seitz thought she’d be doing after graduating from the College of Biological Sciences with a degree in microbiology a few years ago. Somehow, though, it’s not too surprising. Seitz is no stranger to the beer industry. Her father worked for Summit Brewery for two decades, and her older brother is a beer distributor. Plus, her microbiology background put her at an advantage when the opportunity to join Surly Brewing’s lab came up. After all, it’s the yeast and bacteria that give beer much of its flavor — for better and worse.

“My siblings and I grew up surrounded by brewing industry culture, going to Octoberfest festivals and drinking copious amounts of 1919 root beer at the Summit Brewing rathskeller, but I had no intention of going into the beer industry,” says Seitz, who planned to pursue a career in healthcare. She ultimately decided against medical school, but her biology bonafides ended up preparing her for her current role all the same.

Standing amidst the towering stainless steel fermenters in Surly’s Minneapolis facility, Seitz’s enthusiasm for her work is evident. Since jumping into the then-new position two years ago, her career has grown in step with the rapidly expanding brewery located in the Prospect Park neighborhood just down the street from the University of Minnesota East Bank campus.

Seitz’s lab sits just off the brewhouse. The small space is packed with petri dishes, pipettes, scientific equipment and, of course, cans of beer. “When I started, there was only a microscope and an autoclave,” says Seitz. “Now there’s a full lab with an incubator, cell counter, and a PCR LightCycler!”

While there’s lots she has learned about the brewing process on the job, Seitz notes that her undergraduate research experiences exposed her to many of the techniques and much of the instrumentation she uses in her job at Surly.

During her tenure with the popular local beer producer, she has played a central role in expanding the lab and creating a rigorous schedule for testing Cynic, Misanthrope, Furious and other evocatively named brews for unwelcome types of bacteria and yeast.

“I definitely want to be part of this industry,” says Seitz. “I want to continue to build this lab, collaborate with others in my field and learn as much as I can.”

For now, that means venturing into the curious world of taste panels. She’s learned how to identify and work with groups of individuals with a particularly sensitive sense of smell who can decode the complex aromas emanating from any given beer, which comes in handy when developing new brews. She also helps train Surly staff in how to create tasting experiences using raw ingredients from Surly’s well-stocked kitchen — oranges, grains, chocolate, herbs, grass — that turn up in the flavor profiles of various Surly beers.

Other flavors and aromas turn up, too. “One of the known aromatic characteristics of Brettanomyces is ‘horse-blanket’ along with other more pleasant notes like pineapple and stone fruit. I have yet to find a horse-loving volunteer to bring one in to train on the full spectrum of aromas of our Brett-fermented beers,” she muses. “If you know anyone, email me!” —STEPHANIE XENOS
Cedar Creek Ecosystem Science Reserve is synonymous with ecosystem ecology, and for good reason. From Raymond Lindeman’s field-shaping insights about food webs and energy in the 1940s to the present-day work of top ecologists David Tilman, Peter Reich, Sarah Hobbie and others, Cedar Creek plays a critical role in advancing our understanding of how we affect the environment and how we can protect the world we live in. Be part of this incredible legacy.

[Link to membership page] z.umn.edu/cedarcreekmembership